

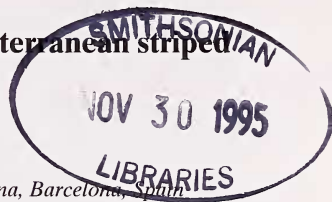
## Geographical variation of body size in Western Mediterranean striped Dolphins (*Stenella coeruleoalba*)

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### Abstract

The variation in maximum body size of striped dolphins, *Stenella coeruleoalba*, was studied in various areas of the Mediterranean Sea. Animals inhabiting the southern part of the Mediterranean are larger than those inhabiting the northern fringe. Although a number of ecological factors affecting maximum body size in mammals has been identified, their role in causing the variation observed is difficult to determine because of the lack of appropriate data. However, the southern fringe is characterized by stronger seasonality and lower density of dolphins, both factors likely to favour larger maximum individual body sizes in a population. The variation observed may reflect population stratification leading to a degree of genetic isolation within the western Mediterranean Sea.

### Introduction

Intraspecific variation in body size occurs in many mammals, including a number of cetaceans. BRODIE (1977) reported that southern baleen whales are larger than their northern hemisphere conspecifics and that body size was inversely correlated with the length of the feeding season but positively correlated with length of the migratory season. In blue and minke whales, the existence of “pygmy” forms with a sympatric distribution in relation to the larger forms has led to the recognition of nominal subspecies (ICHIHARA 1966; BEST 1985). These smaller forms inhabit waters characterized by milder environmental conditions and carry out less extensive migrations. In small odontocetes with a wide geographical distribution, variations in body size within small distances have also been reported. This variation usually occurs among allopatric populations, between offshore and inshore forms (sometimes overlapping in distribution) or between animals inhabiting enclosed or open seas (PERRIN 1984). Difference in water temperatures has also been suggested to affect body size in cetaceans (KASUYA and TAI 1993).

In the present study, variation in body size of the striped dolphin, *Stenella coeruleoalba*, has been studied throughout the western Mediterranean. Understanding of such patterns of variation is a prerequisite to establish the biological characteristics of a population and to determine length parameters associated with reproductive or growth events. Because a number of studies of this type on the striped dolphins inhabiting the western Mediterranean are currently underway, we considered the present research to be relevant.

### Material and methods

Data from stranded or captured striped dolphins from the western Mediterranean and the eastern North Atlantic were compiled from the literature and from a database at the University of Barcelona.

A substantial part of the data originated from the stranding reports regularly published in Spain, France, Italy, Morocco and Algeria during the period 1971–1993 (CAGNOLARO et al. 1986; CASINOS and FILELLA 1975; CARLINI 1888; CENTRO DEI STUDIE CETACEI 1987, 1988, 1989, 1990, 1991; DUGUY 1972, 1973, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983 a, 1983 b, 1984, 1985, 1986, 1987, 1988 a, 1988 b, 1989, 1990, 1992; DUGUY and BUDKER 1972; EL BUALI 1987; GARCIA-CASTILLO et al. 1988; GRAU et al. 1980, 1986; GUIRADO-ROMERO 1991; PELEGRÍ 1980; PEREZ and NORES 1986; PEREZ et al. 1990; RADUAN and RAGA 1982; RAGA et al. 1991; REY and REY 1979; REY and CENDRERO 1979; SEQUEIRA et al. 1992; TXEIXEIRA 1979).

In order to restrict the analysis to adult individuals, and taking into account that previous studies on reproduction of this population suggested that sexual maturity is attained at a length of about 190 cm in both sexes (CALZADA unpubl. data), only those individuals longer than 195 cm were included in the data subset used in the analyses. This data subset contained information from 291 dolphins (157 males and 134 females) from the Mediterranean Sea and 96 dolphins (41 females and 55 males) from the Atlantic Ocean.

Initially, the western Mediterranean basin was divided into 8 subsectors (Fig. 1). An exploratory screening of the frequency distributions of lengths of individuals originating from each of these subsectors was carried out separately, but absence of variation in maximum body lengths between some of these subsectors was observed. Data were then pooled into larger areas because splitting of dolphin body-size data into small, oceanographically homogeneous subareas (corresponding with oceanographic divisions), would produce an extremely small sample size for each subarea and make the statistical analysis unreliable. Because data distributions had been truncated in their lower tails and were therefore expected to depart from normality, statistical comparisons between sectors were performed using nonparametric Kruskal-Wallis and Mann-Whitney tests.

## Results

Preliminary analysis of the data suggested an increase in body lengths from north to south but an absence of variation from east to west. Therefore, we pooled body lengths from dolphins originating from subsectors located at the same latitude but different longitude. However, because efficient networks to collect strandings had not been developed in the central or southern fringes of the basin, the sample sizes of these areas were too small to allow robust comparisons. Therefore, the final analysis was performed combining the southern and central fringes and comparing the resulting subset with the northern one. Body length of dolphins below parallel 41°N (Fig. 1) was found to be significantly

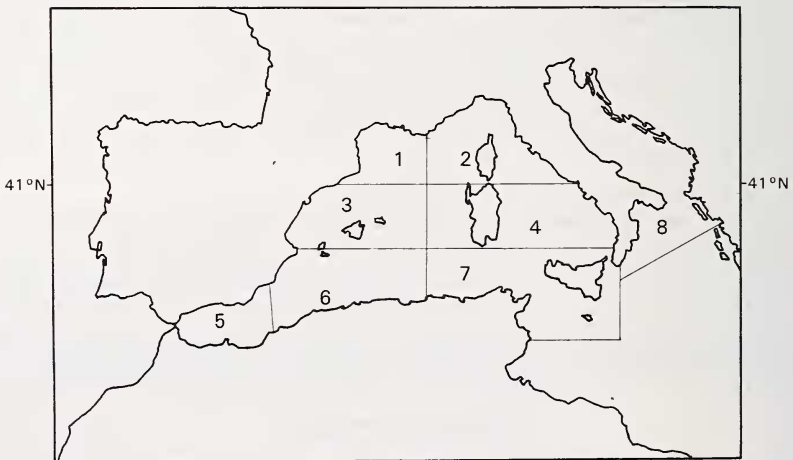


Fig. 1. Study area showing the divisions into 8 subsectors.

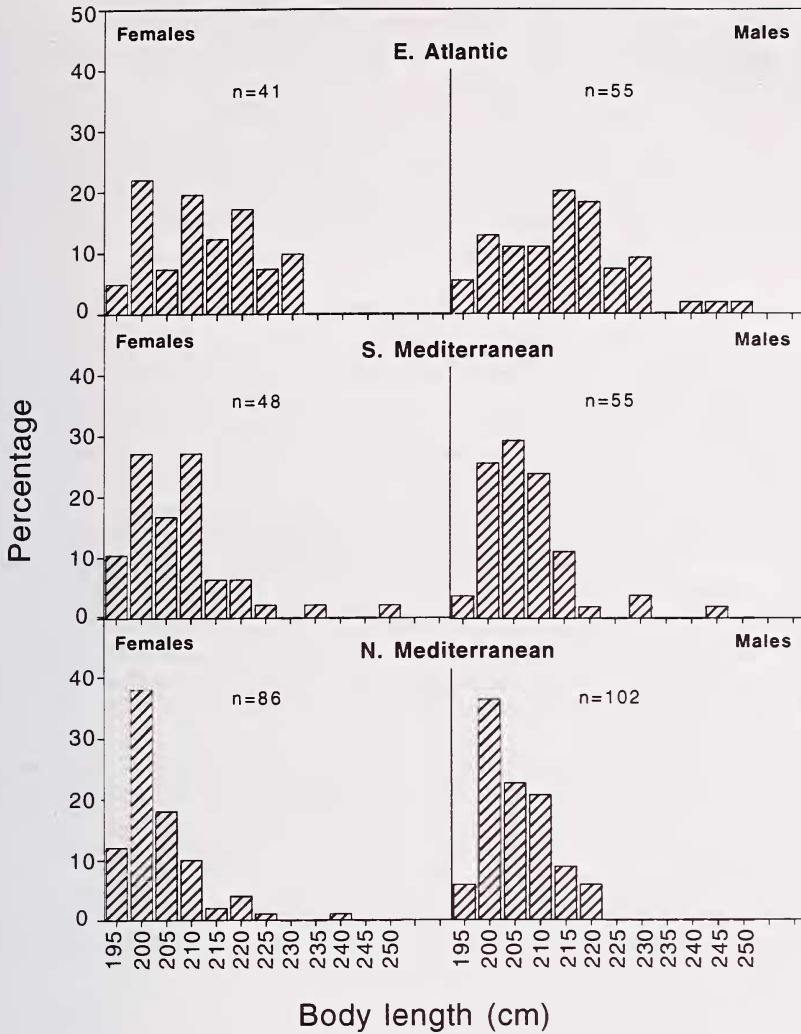


Fig. 2. Frequency distributions comparing the difference between maximum body size in males and females of the northern and southern fringes of the Mediterranean and the eastern Atlantic.

larger ( $p < 0.05$ ) than that of dolphins originating north of this line, the difference being about 3 cm (Fig. 2).

This latitudinal cutpoint is, however, an artificial segregation of the data to facilitate statistical analysis, and body lengths actually increased progressively from north to south. Thus, maximum body lengths were attained in the southern fringe of the distribution range of the species. It should be pointed out that length distributions of southwestern Mediterranean striped dolphins were also significantly different ( $p < 0.001$ ) from those of dolphins inhabiting the eastern North Atlantic, the latter being 5 to 8 cm longer than the former (Fig. 2). Since no variation in body size was found between the eastern and western sectors, the latitudinal cline observed in body lengths cannot be considered to be

caused by an influx of dolphins from the Atlantic, passing to the Mediterranean through the Straits of Gibraltar, but rather to intrinsic variation in individuals inhabiting the western Mediterranean basin.

Males were found to be on average 2 cm longer than females, the difference being significant ( $p < 0.02$ ) both in the northern and in the southern fringes. Such sexual dimorphism in body size positive to males is common to most odontocetes (e.g. EVANS 1987) and probably reflects polygynic behaviour in species inhabiting environments with patched distribution of food resources (JARMAN 1983; VAUGHAN 1986).

## Discussion

Body size among homeotherms is greater in seasonal environments because they have greater lipid reserves which favours survival during periods of food shortage (e.g. McNAB 1974; BRODIE 1977; LINDSTEDT and BOYCE 1985) and also, high mortality during seasonal food shortage reduces competition for resources, favouring larger sizes in survivors (ASHMOLE 1963; BOYCE 1979). Because instability is greater in the southern basin of the western Mediterranean than in the northern basin, a greater selective pressure for large body sizes is to be expected in the southern fringe. This variability may be caused by the influx of Atlantic water, which enters through the straits of Gibraltar into the Alboran Sea creating an anticyclonic gyre. This gyre is characterized by high temporal variability in extent, shape, strength and location (LE VOURCH et al. 1992). The Algerian basin acts as a buffer zone interfering with the Atlantic water that reaches the northern fringe (ESTRADA et al. 1985; LE VOURCH et al. 1992). Because of this barrier, the level of instability induced by the Atlantic influence is lower in the northern fringe than in the southern and could favour larger sizes in the latter.

Furthermore, low population densities are known to affect individual body size by reducing competition for resources and, therefore, favour the achievement of larger size (ROSENZWEIG 1968; LAWTON 1989). In this sense, recent surveys of striped dolphins in the western Mediterranean have estimated the density of this species in the northern fringe as 0.209 individuals per square km (FORCADA et al. 1994), almost doubling the 0.115 dolphins per square km estimated for the southern fringe (FORCADA 1995). Therefore, variation in dolphin density may also be adduced to explain the differences in striped dolphin body size observed between the northern and the southern fringe of the Mediterranean.

Moreover, Bergmann's rules states that warm-blooded vertebrates tend to be larger in colder climates than the ones living in warmer climates (MAYR 1963), the explanation being that larger individuals have a smaller surface-to-volume ratio which lowers their rate of heat loss. Several investigators have criticized and found exceptions to this rule (e.g. SCHOLANDER 1955; McNAB 1971). In the western Mediterranean, data on surface water temperature are fragmentary, but, contrary to what might be expected from the size of the animals, the southern fringe, both in summer and winter, appears to be between 2 and 3°C warmer than that of the northern fringe (ANONYMOUS 1990). Although this variable does not appear to play a role in the variation observed in striped dolphin body size, instead of attempting to explain size variation by considering only adaptation to cold, selective pressure for larger body size may rather be due to a combination of different climatological variables. Besides, SCHOLANDER (1955) argued that adaptation to cold depends mainly on improved insulation rather than on heat conservation and that small increases in body size will have little effect.

Finally, in mammals, size of available prey has also been positively correlated with predator size (McNAB 1971; SEARCY 1980) and this has also been observed in odontocetes (ROSS 1984; CLARKE 1980). Unfortunately, no information is available to test this hypo-

thesis in the western Mediterranean striped dolphins. Studies carried out in the Liguro-Provezal basin indicate that striped dolphins are generalist eaters; cephalopods and bony fishes represent the regular source of food, although crustaceans are occasional prey (PULCINI et al. 1992; WURTZ and MARRALE 1991, 1993). The fauna of the southern fringe of the western Mediterranean include a number of species of Atlantic origin on which striped dolphins may feed. Taking into account the generalistic feeding of the species, it is likely that the diet of the dolphins inhabiting this area will be quite different from that of dolphins living in the northern fringe. However, no food studies are available for the southern waters, so it is not possible to ascertain the effect, if any, of prey size on dolphin body size.

Establishing relationships between ecological variables and body size of animals is complex, with many apparent exceptions occurring (PETERS 1991). However, the increase observed in body size from north to south may be examined taking into account some general, although gross, latitudinal trends in the factors mentioned above. Further research on the role played by these, and other as yet unidentified, variables may clarify their actual involvement in the variation observed in body size. However, although the mechanisms eliciting such variation have not been totally clarified, caution should be applied to the estimation of population parameters linked to body length or growth parameters. Data from striped dolphins originating in a given area of the western Mediterranean should not be combined with those coming from another.

Moreover, the existence of geographical variation could be indicative of a certain degree of genetic isolation among different areas of the western Mediterranean. Recognition of this fact is relevant for the management of the population or populations of the species. Particularly, the significance of mortality associated with fishing operations or epizootic diseases, two main problems currently affecting Mediterranean striped dolphins (NOTARBARTOLO DI SCIARA 1990; AGUILAR and RAGA 1993), should not be evaluated on a global scale for the whole western Mediterranean but, rather, the impact should be measured on a small-scale, local perspective.

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### Zusammenfassung

#### *Geographische Variationen der Körpergröße von Streifendelphinen (Stenella coeruleoalba) im westlichen Mittelmeerraum*

Diese Studie untersucht die Variationen der maximalen Körpergröße von Streifendelphinen, *Stenella coeruleoalba*, im Bereich des Mittelmeeres. Die im südlichen Teil des Mittelmeeres lebenden Tiere sind länger als die des nördlichen Bereiches. Obwohl eine gewisse Anzahl von ökologischen Faktoren festgestellt wurde, die die maximale Körpergröße von Säugetieren beeinflussen, kann deren Rolle in der beobachteten Variation nur schwer beurteilt werden, da die notwendigen Daten fehlen. Jedenfalls besteht im südlichen Raum eine stärkere Saisonabhängigkeit und niedrigere Dichte der Delphinpopulation, beides Faktoren, die ein größeres Körpermaß der Individuen beeinflussen. Die beobachtete Variation könnte auf die Existenz einer Bevölkerungsschicht deuten, die zu einer genetischen Isolation innerhalb des westlichen Mittelmeeres führt.

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